up and surgical sequence. We chose a median sternotomy incision, believing it offered the best exposure for complete excision of the tumor, as well as redoing the bypass grafts. CPB was established via groin cannulas to support the heart during the redo sternotomy. Manipulation of the divided sternum was minimized, because thymomas can adhere to mediastinal structures, even without real invasion. Traction on the tumor or the vein graft might have led to an intraoperative myocardial infarction. Alternatively, a thoracotomy or thoracoscopy could have mobilized the mediastinum from the undersurface of the sternum before sternotomy, but we thought that this did not provide sufficient safety should the vein graft occlude.

A favorable outcome was achieved in this case by (1) preoperative coronary arteriography, (2) femoral CPB before the redo sternotomy, and (3) no manipulation of the tumor or graft before cardioplegia.

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EXTERNALLY SUPPORTED RADIAL ARTERY GRAFT FOR MYOCARDIAL REVASCULARIZATION: A NEW TECHNIQUE TO AVOID VASOSPASM

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The radial artery was proposed as a conduit for coronary artery bypass many years ago,[1] but its use was abandoned some years later because of a high incidence of arterial spasm, leading to narrowing or early graft occlusion. The development of new antispasmodic drugs led some surgeons, including us, to reevaluate the use of the radial artery for coronary artery bypass grafting, because arterial grafts are know to be more resistant to atherosclerosis than are autogenous vein grafts.[2,3] However, despite significant advances, such as improvements in radial artery removal technique and the use of calcium channel blockers, arterial spasm still may occur, causing concern for several surgeons.[4] The aim of this report is to present a new technique that eliminates radial artery spasm when the artery is used as a coronary artery bypass graft.

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Patients and methods. The Biocompound-graft (Alpha Research GmbH, Berlin, Germany) was developed as a new type of hybrid prosthesis, consisting of a highly flexible mesh tubing and the patient's own vein. Its primary indication is for coronary artery bypass, using venous bypass grafting, in patients with irregularly shaped veins.[5] To our knowledge, this is the first report of this technique being used for an arterial graft. Detailed information and instructions for making and implanting the Biocompound-graft are available from the manufacturer.

The radial artery was harvested in a standard manner with topical application of warm saline solution and papaverine (1 mL/100 mL 0.9% NaCl). The harvested artery was then prepared with the external support. In brief, the composite graft, consisting of a mesh tubing and the radial artery, is constructed with a fibrin adhesive. The Biocompound-graft is extremely pliable, made of individual filaments, 32 μm thick, manufactured from a high-grade steel alloy (Phynox; Vena Tech, Evanston, Ill). After removal of the radial artery, a long, thin balloon catheter is carefully inserted through the distal end of the radial artery up to the proximal end. The applicator set with the Biocompound-graft mesh tubing is slipped over the radial artery, and the applicator is gently pushed off, leaving the mesh over the entire radial artery. The balloon is then gently inflated with isotonic solution, and the Biocompound-graft mesh is smoothed out starting at the middle of the balloon catheter and working toward both ends of

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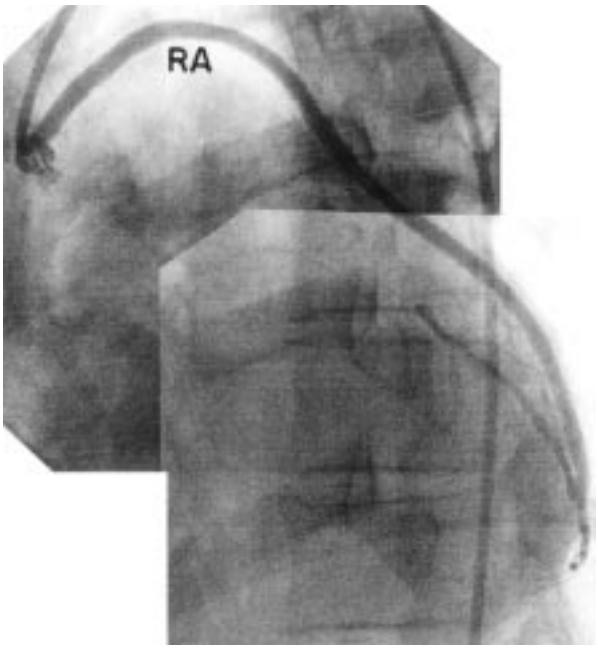

Fig 1. Patient 1. Postoperative angiogram with a selective injection at the externally supported radial artery *(RA)* graft, demonstrating its proximal anastomosis to the aorta and its distal anastomosis to the posterior ventricular branch of the circumflex artery.

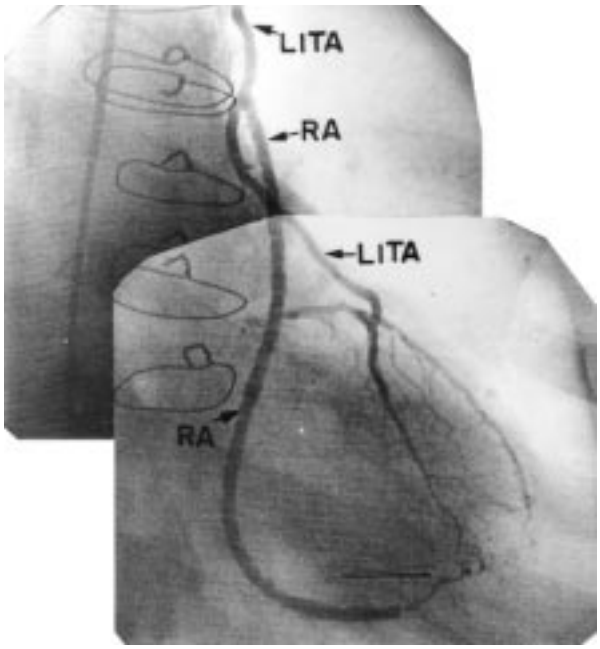

Fig 2. Patient 2. Postoperative angiogram with a selective injection at the left internal thoracic artery (LITA), demonstrating its distal anastomosis to the left anterior descending coronary artery. LITA anastomosis with the externally supported radial artery *(RA)* graft and distal anastomosis between the radial artery and the second marginal branch of the circumflex artery can also be identified.

the artery. A fibrin glue (human fibrinogen, bovine aprotinin, and human thrombin [Tissucol]; Immuno, Rio de Janeiro, Brazil) is applied in 2 steps. First, the fibrinogen component is applied along the entire length of the graft, followed by the thrombin component in a similar manner, to assure completion of the adhesion process. This process is repeated 3 times, rotating the graft to give uniform coating. The balloon is then deflated and carefully removed. After a few minutes, the radial artery graft has good consistency and elasticity and is uniformly dilated. Finally, the radial artery with the expanded mesh incorporated to its external wall is handled like a standard internal thoracic artery (ITA) or vein graft. We did not use calcium channel blockers in the postoperative period.

Clinical summaries

PATIENT 1. A 45-year-old man with unstable, multivessel coronary artery disease underwent myocardial revascularization. The externally supported radial artery was used with its distal anastomosis to the posterior ventricular branch of the circumflex artery. The proximal anastomosis was performed to the aorta (Fig 1). Additional grafts used were the left ITA to the left descending anterior artery and a saphenous graft to the first diagonal branch.

PATIENT 2. A 68-year-old man with unstable, multivessel coronary artery disease underwent myocardial revascularization. The distal anastomosis between the externally supported radial artery was to the second marginal branch of the circumflex artery, and the proximal anastomosis was to the proximal portion of the left ITA, which was used to revascularize the left anterior descending coronary artery (Fig 2). The descending posterior artery received a saphenous graft.

Both patients had an event-free postoperative course and were discharged after 1 week. There were no hemodynamic, enzymatic, or electrocardiographic alterations. Angiography, performed on the fourth postoperative day, showed that, in both patients, all grafts were patent. The radial artery grafts showed a good diameter, with no signs of spasm or constrictions (Figs 1 and 2).

Discussion. Although the pedicled ITA remains the primary arterial conduit for myocardial revascularization, the externally supported radial artery, as we have prepared it, seems to be an excellent alternative as a bypass conduit, with all the advantages inherent in arterial compared with venous grafts. The technique for external support has been successfully used to improve varicose veins for coronary artery bypass grafting.[5] To our knowledge, this is the first report of its use in the radial artery to avoid spasm. The technique is easy to perform and results in excellent diameters, similar to good saphenous vein grafts (Fig 1, *A*). For women or patients with a small radial artery diameter, a smaller-diameter biocompound system will need to be developed. Long-term follow-up is required to establish the benefits of this technique and to better define whether the external support of the radial

artery can be added to the armamentarium of surgeons dealing with coronary artery disease.

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SYMPTOMATIC CORONARY-SUBCLAVIAN STEAL SYNDROME: REPORT OF A CASE WITH COMPLETE OCCLUSION OF PROXIMAL LEFT SUBCLAVIAN ARTERY AND ANOMALOUS ORIGIN OF LEFT VERTEBRAL ARTERY FROM THE AORTIC ARCH

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A case of severe resting angina in a patient with a patent left internal thoracic artery (LITA) graft on the left anterior descending coronary artery (LAD), complete occlusion of the proximal left subclavian artery, and anomalous origin of the left vertebral artery from the aortic arch is presented. The clinical picture, hemodynamic pattern, and treatment are described.

A 75-year-old man was admitted with resting angina. Eleven years earlier, the patient had undergone coronary artery bypass grafting (CABG) with the LITA artery to the LAD and saphenous vein grafts for the first diagonal, obtuse marginal, and right coronary arteries. Over the past 1½ years he had been having exertional angina, and its severity had dramatically increased over the past month. Chest pain could easily be provoked by mild exercise and exacerbated by selective exercise of the left upper limb. Furthermore, during exercise the patient had cramping of the left arm, whose severity increased over time, with symptoms of rest pain during the past month. No symptoms of vertebrobasilar insufficiency could be recorded. As evinced from the patient's file, at the time of the previous operation no difference in pressure between the two arms was recorded and intraoperative assessment of LITA flow was optimal. Preoperative brachiocephalic arteriography was not performed, but a postoperative cineangiogram obtained 1 year after CABG surgery showed perfect patency of the LITA and absence of significant stenosis on the left subclavian artery.

At physical examination the left humeral pulses were absent and the left arm was cold and pale. The patient maintained a peculiar position, resting his left arm on his right arm to alleviate the pain. Arterial pressure in the left arm could not be recorded, whereas pressure in the right arm was 176/95 mm Hg.

An electrocardiogram revealed myocardial ischemia in leads V_1 to V_5 with an ST-T segment depression of 2 mm; ischemic changes could be exacerbated by mild exercise of the left arm. Cardiac enzymes were within normal limits. Echocardiography showed mild anterolateral wall motion abnormalities. Arterial Doppler echography showed normal flow in the vertebral arteries. No subclavian steal was demonstrated, and no abnormalities of the carotid and vertebral arteries were recorded, although the left humeral artery showed extremely low flow. According to cardiac catheterization, the coronary anatomy had not changed since the CABG operation. Important proximal stenoses were present on the LAD, in its major diagonal branch, in first the obtuse marginal, and in the right coronary artery. Selective graft opacification showed patent saphenous vein grafts. Visualization of the LITA was not possible because of proximal occlusion of the subclavian artery. Patency of the LITA could be demonstrated by retrograde opacification of the vessel during selective catheterization of the LAD (Fig 1). The distal subclavian artery was visualized by retrograde opacification of the LITA. The left vertebral artery took origin directly from the aortic arch (Fig 2). By direct opacification of the vertebral artery, the distal subclavian artery could be

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